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THE REACTIONS OF SOME POTATO VARIETIES AND SEEDLINGS TO POTATO VIRUS F[1]

James Munro[2]

Potato virus F ("tuber blotch virus") can probably be found wherever potatoes are grown. Although carried by many varieties without showing symptoms, it may be one of the commonest causes of tuber necrosis.

Interveinal mosaic of potato, first described by Quanjer (7), was shown by Loughnane and Clinch (4) to be a complex of potato virus X and the tuber blotch virus. Murphy (6) described the symptoms of interveinal mosaic on potatoes as being, "a characteristic grey color with a mottle that is typically interveinal and easily visible; the leaves are flat and not puckered or curled down". He considered the disease to be one of the severe but less common mosaics. In 1936 the tuber blotch virus was renamed potato virus F (2).

Apart from a 1941 paper by Clinch (1) describing an extremely severe strain of virus F and naming the disease "virulent tuber blotch", only passing references have been made to this virus since that time. But doubt still remained as to whether the presence of potato virus F could always be recognized in the diagnostic hosts described. According to Clinch *et al.*, the symptoms induced by virus F strains in potato foliage in general are mild and erratic in appearance (2). The same can be said of the reactions to the virus in many other solanaceous hosts (5). This paper presents the results of further studies with this virus in a range of potato varieties and seedlings.

Materials and Methods

Two strains of the virus were used. One was found occurring naturally in the European variety Southesk (5), and the other was kindly supplied by Dr. Phyllis Clinch of University College, Dublin, Eire.

The Southesk strain was taken from its original source to White Burley tobacco to eliminate potato virus S. The virus was thereafter maintained in White Burley tobacco plants (Fig. 1). Similarly, the Clinch strain was taken from an original source, an Arran Banner plant free from potato virus X, to White Burley tobacco. Thereafter all initial experimental inoculations with these strains were made with sap from infected White Burley tobacco. The scions infected with virus F were obtained from potato seedlings that are top necrotic (3) to viruses A and X.

The Clinch isolate was obtained as a known strain of potato virus F, and the Southesk isolate was shown to be a strain of this virus. Plants systemically infected with one strain resisted invasion by the other. Tests with antisera made separately against these two strains as antigens showed that they were serologically related. By these criteria they were regarded

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as being strains of one virus. Differences between strains could not be detected in the foliage of any of the potato plants used.

Mechanical inoculations were made after the leaves of the plants had been dusted with 400-mesh Carborundum to facilitate transmission.

Top-cleft grafts were made and, without further treatment or excess watering, covered immediately with polyethylene bags, each grafted plant being bagged separately. The mouth of the bag was secured around the lower part of the pot with an elastic band. Grafted plants treated in this way were left for a week or less in the full light and heat of the greenhouse without water or any other attention. After this period, the graft unions were usually sufficiently complete to permit removal of the bags and to permit subjecting the plants only to the greenhouse routine care and treatment.

As preliminary work had shown that White Burley tobacco is an unreliable indicator for virus F, some 40 other solanaceous species were tested in the quest for a more suitable one. *Solanum miniatum* Bernh. was finally chosen because symptoms were clearly specific and their development unaffected by seasonal changes (5).

Wherever reference is made in this report to symptomless plants and tubers being infected, confirmatory tests had ben made. Potato plants were tested by using juice from their crushed leaves to inoculate *S. miniatum* plants. The eyes from the cut parts of each tuber were planted and the resulting foliage tested in like manner.

Symptomatology

Potato Varieties and Seedlings

Thirty potato varieties and seedlings were used; these included internationally known commercial varieties and seedlings of value as breeding material. They are classified according to their reaction to virus X.

Those susceptible to virus X were Arran Banner, A. Consul, A. Peak, A. Pilot, Canso, Catriona, Chippewa, Dunbar Yeoman, Gladstone, Golden Wonder, Katahdin, Kennebec, Keswick, Majestic, Record, Sebago, Teton, Ulster Premier, Australia C.S.I.R.O. seedling 11-76, Canada Department of Agriculture seedlings F451 and F4519, and 3 U.S.D.A. seedlings (B596-76, B926-9, and N.D. 457). All plants used were initially free from virus X. Those immune from virus X were Saco and U.SD.A. seedlings 41956 and B606-37. Those top-necrotic to virus X were Epicure and Scottish Plant Breeding Station seedlings 834C(29) and 1256A(23).

Mechanical Inoculations

When potato varieties and seedlings were infected by inoculation with either strain of virus F, no symptoms of disease were observed in any potato plant that was free from other detectable viruses at the time of inoculation; the tuber progeny also produced symptomless but infected plants.

← Fig. 1.—White Burley tobacco infected with virus F.

Fig. 2.—Golden Wonder variety; left, infected with virus A; right, infected with same strain of virus A and with virus F.

Fig. 3.—Arran Banner variety; tuber necrosis after 6 months in storage.

Graft Inoculations

Graft inoculations were made with scions infected with virus F alone and only to plants that were known to be top-necrotic to, immune from, or free from virus X.

When these strains of virus F were separately introduced into a range of potato varieties by graft, the reactions were much more severe than those following mechanical inoculation of the same varieties or seedlings. In some respects the symptoms resembled a combination of the slowly developing top-necrotic reaction caused by virus A in a hypersensitive plant and the lethal necrosis reaction of certain potato varieties to some virus Y strains. After about three weeks, a coalescing necrosis had spread over the leaves of the side shoots immediately below the graft union. Initially, the necrotic areas were distinct and black and had some resemblance to the top-necrosis development. The necroses, however, quickly dried out to give a brown, hard, shriveled appearance. As this reaction progressed, numerous brown lesions developed on the main stem and other side shoots of the stock. The leaflet tips and edges became severely scorched; blotches appeared, enlarged, and coalesced. The leaves then shriveled and hung on the plant as the disease developed progressively upwards. But the complete process was a comparatively slow one, and the full top necrotic reaction was not always completed in spring and summer tests. Two to three months elapsed from the time of graft union until the necrotic reaction ceased. The progeny plants from these grafted stocks were symptomless, but the virus was present.

In the autumn the reaction in some varieties, such as Epicure, was so rapid that necrosis of the stem below the graft union sometimes caused the full green turgid scion to topple over. In several other Epicure plants, the graft stem and a second stem of the same plant were shriveled and dead, and random leaves on a third stem dried up within two weeks after the graft was made.

Tuber Necrosis

Infected tubers of the 30 seedlings and varieties were examined after being stored for varying periods up to one year. Occasional tuber necroses were found in only four varieties of those infected with the Southesk strain. Most of the tubers infected with the Clinch strain had tuber blotch, and it was especially severe in virus-X-free Arran Banner (Fig. 3).

Dual Infections

When potato plants already infected with virus X were inoculated with virus F, brown necrotic lesions and blotches developed on most leaves of the plants. When a symptomless strain of virus X was used in combination with virus F, only brown necrotic lesions and blotches appeared (Fig. 5). When the strain of virus X caused a visible mottle however, a rugosity together with the brown lesions developed throughout the plants infected with the two viruses (Fig. 4). This rugosity varied in intensity with the severity of the virus X strain used. An accidental infection with virus X of seedling 1256A(23) already infected with F caused the top-necrotic reaction typical of virus X infection in the plant. Brown necrotic lesions also developed; these were not observed in any

FIG. 4.—Kennebec variety; left, infected with virus F and a more severe strain of virus X; right, infected with the same strain of X alone.

FIG. 5.—Canso variety; infected with virus F and a symptomless strain of virus X.

potato plants of the listed varieties and seedlings that were infected with virus F alone following sap inoculation.

When potato plants already infected with potato virus A were inoculated with virus F (Fig. 2), the symptom reaction was similar to that caused by joint infections with viruses X and F. Plants already infected with any one of 6 strains of potato virus Y also developed brown necrotic lesions when sap-inoculated with virus F. This was in addition to the peculiar symptoms caused by the infecting virus Y strain.

Results of combining virus F with any one of these 3 viruses indicated a constancy in the symptom trend. The large, brown, coalescing lesions appeared on most leaves of the potato plants jointly infected with virus F and any one of the viruses A, X and Y. Because of the constancy of these symptoms, peculiar to an infection with virus F and another potato mosaic virus, a practical use was made of this phenomenon.

A number of seedlings from specific crosses are received in the tuber stage each year from the Canada Department of Agriculture potato breeder.[3] Each seedling is separately tested for its reaction to viruses A and X. Tests are made by top-grafting 2 plants of each seedling with a scion infected with a mixture of common field strains of virus X, two plants with a scion infected with the B strain of virus X, and two plants with a scion infected with virus A. A rapid necrotic destruction of side shoots of the grafted plants indicate in each case that the seedling is top-necrotic to the virus in the scion. The necrotic reaction to virus X is usually advanced sufficiently for determinations within two weeks after grafts have been made, but with virus A the determinations may not be apparent until 4 weeks after grafts have been made. To expedite determinations of seedling reaction to these viruses, the stocks of all grafted plants not showing top-necrotic symptoms were inoculated with virus F about two weeks after the grafts were made. This caused either symptoms of dual infection, indicating susceptibility to viruses A or X, or it hastened the appearance of top-necroses in the hypersensitive seedlings. This method was also used to detect susceptible seedlings in progeny from specific crosses for virus X immunity. Although the addition of virus F to grafted seedlings susceptible to virus X invariably caused the peculiar synergistic effect, occasional seedlings that are immune to virus X also developed these symptoms.

Discussion

In some hosts potato virus X is extremely sensitive to the presence of any one of certain other viruses. Concurrent infections with one of these viruses and virus X cause diseases that are much more severe than the additive effects of both. Examples of such combinations with virus X are obtained with potato viruses A and Y. Studies of some double infections have shown that a greater amount of one component virus is present in doubly infected plants than in plants infected with one of the viruses alone (8). When potato plants are inoculated with viruses X and F together or viruses F and A, necrotic symptoms develop that are similar to an intensification of symptoms caused by virus F alone in other solanaceous

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hosts (5). But there is a constancy in the kind of symptoms caused by the intensifications of X and F together, and of A and F together. This is not the case in all combinations of strains of virus X with strains of virus Y in potato plants.

Consequently the complementary method of using virus F as a stimulator to reveal the susceptibilities of potato seedlings to viruses A and X can be of value. Determinations can be made more quickly and there is no need to inoculate back to other test plants to confirm susceptibilities. Further, there is no demand on greenhouse space for back-testing plants, or a need for serological tests.

The rapid necrotic destruction of potato plants following a graft suggests that a quickened multiplication or movement of virus particles follows this form of inoculation. This could be due to direct entry of the virus into the distributing system of the plant in relatively large amounts, permitting infiltration of cells with particle numbers beyond the assimilating or controlling facilities of individual cells. In contrast, the gradual infiltration into cells from centers of infection produced by rubbing inoculation may enable the entered cells to prevent the final virus particle content from reaching the point of cell intolerance and necrotic breakdown.

Although potato virus F has long been known as a cause of tuber necrosis in commercial potato varieties, it is still considered to be of little economic importance. Perhaps this is because there are many other indeterminate causes of tuber necroses. The present results suggest that the presence of the virus in a growing crop can only be detected when plants are jointly infected with another potato mosaic virus such as virus X; however, as virus X is ubiquitous and commonly symptomless in commercial potato crops, the presence of virus F in most crops should be apparent. But as close inspection of growing crops is usually confined to those entered for seed certification, true identification of the cause of a virus F infection may be limited to these crops. To a casual glance, the symptoms of joint infection with these two viruses may be confused with mechanical or chemical injury, or even, in some advanced cases, with nutrient deficiency.

There may be some doubt as to the prevalence of virus F in the field, but there is little in regard to what reduction in crop it can cause by damage to foliage and tubers.

Summary

Reactions caused by infections with virus F alone and jointly with each of the viruses A, X and Y were studied in 30 potato varieties and seedlings. Infections resulting from mechanical inoculations with virus F alone to virus-free plants did not cause symptoms, but severe necroses developed when the plants were graft inoculated. When plants were inoculated jointly with virus F and potato virus A, X or Y, brown necrotic lesions and blotches developed on most of the leaves. Similar symptoms developed when plants already infected with any one of these 3 viruses were mechanically inoculated with virus F.

One strain of the virus caused tuber necroses in all of the potato plants inoculated; tuber necroses were found only in four varieties when infected with the other strain.

A routine method was developed to expedite seedling tests for hypersensitivity to viruses A or X by the added use of virus F.

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EFFECTS OF VIRUSES AND OTHER POTATO DISEASES ON CHIP COLOR[1]

H. W. CHAPMAN AND C. W. FRUTCHEY[2]

Potato chippers commonly select and discard a considerable quantity of the chips going through their fryers as off-color or too dark for sale when compared with the bulk of the chips from a given lot of potatoes. These discarded chips as well as the labor involved in picking them off the chip lines represent a considerable loss to the processor. The dark coloration of undesirable chips is often attributed to disease within the potato tubers used in chipping. Jones (1) showed pictures of whole tubers, raw slices, and fried chips obtained from tuber lots having many common potato diseases. However, more critical information is needed regarding the influence of specific potato diseases on the color and quality of the finished chip.

MATERIALS AND METHODS

Several potato varieties known to be virus infected[3] along with apparently healthy plants of the same varieties were grown during the 1958 and 1959 seasons at Wiggins in northeastern Colorado and at Center in the San Luis Valley[4] (Table 1). No attempt was made during the growing season to provide isolation or prevent current season disease spread in these plantings. Each year's tuber crop was harvested and subjected to standard uniform chipping tests in the laboratory at Fort Collins.

In addition, field inspectors of the Colorado Potato Certification Service collected both diseased and healthy hills of potatoes from fields throughout the state during the second inspection in 1959. These samples were also processed at Fort Collins.

Two hundred grams of raw slices were picked at random from the sliced potatoes, of each of the diseased and healthy tuber lots. After washing in cold tap water they were drained and fried until bubbling ceased in 15 lbs. fat at the starting temperature of 171° C. A 25 gram raw sample was incorporated in 150 ml of 95 per cent ethonol and then blended for 1 minute in a Waring blender. After settling the supernatant solution was used for reducing sugar analysis. Hassid's ferrocyanide method was used. Chip color was determined with a Gardner-Hunter Color Difference Meter, using a light yellow #C-LV-1305-58 standard. The chips were crushed into small pieces and then pressed to give an integrated color measurement.

RESULTS AND DISCUSSION

Chips from tubers infected with leaf roll, or spindle tuber virus were

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[3]Supplied through the courtesy of Dr. R. E. Webb and Dr. L. A. Schaal, USDA ARS.

[4]We are indebted to Mr. James Twomey for planting and caring for the potatoes at the Demonstration Farm at Center, Colorado.

as light colored as those from the healthy hills (Table 1). These chips were all light enough in color for commercial sale, except for the Green Mountain variety which is seldom used for chipping.

TABLE 1.—*Color of potato chips from tubers infected with spindle tuber or leaf roll virus as compared with healthy checks.*

Variety	Disease	Rd color score[1]			
		1958 Crop		1959 Crop	
		Wiggins	Center	Wiggins	Center
Kennebec[2]	healthy	40.2	36.0	36.8	23.8
Kennebec[2]	spindle tuber	..	..	31.8	23.0
Kennebec[2]	leaf roll	39.7	33.9	34.9	27.0
Cobbler	healthy	34.9	29.3	35.8	27.4
Cobbler	spindle tuber	35.9	26.3	32.6	25.4
Cobbler	leaf roll	34.5	28.4	32.2	26..3
Chippewa	healthy	34.5	29.1	33.8	26.0
Chippewa	spindle tuber	34.3	30.8	33.8	23.7
Chippewa	leaf roll	36.1	34.1	35.8	28.8
Saco	healthy	34.9	..	30.5	29.5
Saco	spindle tuber	36.5	31.1	32.8	42.1
Katahdin	healthy	35.9	34.4	29.5	33.2
Katahdin	spindle tuber	35.3	25.3	35.3	34.2
S 41956	healthy	35.5	36.2		
S 41956	spindle tuber	36.1	30.6		
S 41956	leaf roll	36.4	31.7		
Green Mountain	healthy	..	21.7	29.7	24.5
Green Mountain	spindle tuber	32.5	27.1	33.4	29.7
Green Mountain	leaf roll	..	29.8	30.4	33.0

[1]Mean reading of commercial chips from six different sources 35.
[2]Seed potatoes of known virus disease content supplied by Dr. R. A. Webb and Dr. L. A. Schaal, USDA ARS.

The samples collected by inspectors from certified seed fields were all somewhat immature when dug. However, relative differences between healthy and diseased hills would still be expected to exist (Table 2). Likewise no differences were apparent in the color of chips from healthy and leaf roll or spindle tuber infected hills. Mosaic and calico infected hills, although not enough samples were obtained for adequate tests, also showed no measurable effect on the color of potato chips.

Giant hill and haywire infected plants produced tubers that invariably made darker colored chips than the healthy checks. These diseases, whatever their nature and effect on tubers, may be expected to result in off-color potato chips. In fact, any disease or condition that may cause differences in maturity within a field may result in nonuniformity of chip color from that lot of potatoes. In addition, it has been observed that tubers with a net necrosis due to aster yellows virus or current season infection with leaf roll virus also produce off-color potato chips. Chips made from tubers infected with blackleg bacteria were slightly darker than

TABLE 2.—*Effects of various diseases on per cent reducing sugar content of tubers and color of potato chips, 1959 crop.*

Disease[1]	No. of samples	Reducing sugar — wet basis Per cent	Mean Rd color score[2]
Healthy	2	.33	29.3
Mosaic	2	.25	30.1
Healthy	4	.32	25.7
Giant Hill	4	.66	17.6
Healthy	2	.21	25.2
Haywire	2	.89	13.2
Healthy	6	.36	27.4
Spindle tuber	6	.42	25.7
Healthy	12	.31	26.9
Leaf roll	12	.36	27.6
Healthy	1	.68	15.4
Calico	1	.57	19.1
Healthy	3	.22	26.8
Blackleg	3	.23	23.3
Healthy	4	.20	27.6
Fusarium	4	.31	25.0

[1]Samples collected by field inspectors of the Colorado Potato Certification Service.
[2]Mean reading of commercial chips from six different sources 35.

controls, however, this darkening was found to be concentrated into nearly black areas on the margin of chips which are incorporated into the ground chip sample used for color determination. Likewise, Fusarium discoloration of the tuber vascular tissue incorporated into the ground chip sample resulted in slightly darker readings on the meter. Many such chips are probably sorted out from chip production lines.

CONCLUSIONS

Leaf roll and spindle tuber virus infected tubers can be processed into potato chips as light and uniform in color as those of apparently healthy controls. Tubers from hills showing vine symptoms of mosaic and calico virus also made equally light colored chips as the checks. Haywire and giant hill infected plants can be expected to produce tubers that will chip much darker in color. In addition it has been observed that any condition which results in necrosis of tuber tissue will also produce dark chips.

Blackleg infected tubers produce chips with dark edges while Fusarium infection and the resulting discoloration causes a dark brown ring or portion of a ring in the chip.

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RESISTANCE IN *SOLANUM TUBEROSUM* TO *PSEUDOMONAS SOLANACEARUM*[1]

L. W. NIELSEN AND F. L. HAYNES, JR.[2]

Bacterial wilt and tuber decay of Irish potatoes (*Solanum tuberosum* L.) caused by *Pseudomonas solanacearum* E. F. Smith limits potato production on many infested farms in eastern North Carolina. In this area, the crop is planted in late February and March. Early varieties are harvested in May and June, whereas the harvest of late varieties extends into July. In seasons having average or warmer temperatures, the disease appears during May and additional plants usually become infected until the potatoes are harvested or the plants mature. At the time bacterial wilt first appears, the plants have usually reached maximum vegetative growth and are often, in the case of early varieties, approaching maturity.

It was early recognized that the use of varities resistant to *P. solanacearum* would be the most practical means of control (3). The bacterium is an important soil-borne pathogen of Irish potatoes in warm or subtropical climates around the world. Relatively few efforts have been made to discover sources of resistance to the pathogen or to breed resistant varieties. Furthermore, all commercial potato varieties observed or tested are susceptible to the organism (3). Eddins (2) reported that Katahdin and Green Mountain possess some resistance. When grown in naturally infested soil, the number of plants of these varieties that became infected was not greatly different from that of susceptible varieties; however, the proportion of tubers that became infected was less. It was suggested that these varieties could be successfully grown in soils moderately to lightly infested with the pathogen. In Java, Thung (7) found that Green Mountain, some European varieties, and native varieties were more resistant to *P. solanacearum* in naturally infested soils than was the suseceptible Bevelander. He also studied the resistance of *Solanum andigenum* Juz. and Buk., *S. antipoviczii* Buk., *S. caldasii* Dun., *S. chacoense* Bitt., and *S. demissum* Lindl. and hybrids derived from crosses of these with *S. tuberosum*. The hybrids were less resistant to *P. solanacearum* than were the original *Solanum* species used as parents; however, a greater proportion of the progeny resulting from a back cross to *S. tuberosum* possessed resistance although the level of resistance in most cases did not reach that of the *Solanum species*.

In 1947 a program was initiated in North Carolina to evaluate varieties and clones of *Solanum tuberosum* for resistance to *P. solanacearum*. Nearly 9000 clones were evaluated with field and laboratory procedures. The procedures employed and the resistance found are herein reported. Brief reports covering methods and preliminary results were published earlier (5, 6).

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Contribution from the Departments of Plant Pathology and Horticulture, North Carolina Agricultural Experiment Station, Raleigh, North Carolina. Published with the approval of the Director of Research as Paper No. 1110 of the Journal Series. This program was initiated by Mr. M. E. Gardner and Dr. J. H. Jensen in cooperation with Dr. F. J. Stevenson, Dr. F. D. Cochran also participated in the program.
[2]Plant Pathologist and Horticulturist, respectively.

Materials and Methods

The potatoes tested were largely from stocks maintained by the U. S. Department of Agriculture and the North Carolina Agricultural Experiment Station and progeny from various crosses of these stocks. Resistance to *P. solanacearum* was first evaluated by growing the potatoes in naturally infested soil and later by artificial inoculations under greenhouse conditions.

Field Evaluation of Resistance: Potatoes are planted in naturally infested soil which had been abandoned for Irish potato prodction. A late March planting is used so that the potatoes might develop during warm weather. When planted at this time, early-maturing clones such as Irish Cobbler are expected to mature about July 1. Late-maturing clones normally live until mid- or late-July; however, readings are usually terminated about mid-July. This variation in maturity date for the different clones makes it difficult to compare late- and early-maturing clones in years having relatively cool growing seasons. The early clones mature before a large proportion of the plants become infected, and late-maturing clones with some resistance may have higher disease incidence than early-maturing susceptible potatoes.

Disease readings are made at 1 or 2-week intervals after the disease is discovered. Multiple-stemmed hills of potatoes are rated as diseased if a single stem develops symptoms and bacterial ooze can be squeezed from a cross section of the tap root. Irish Cobbler is used as the susceptible variety with which all other clones are compared.

The basis of selection for resistance is the percentage of hills that remain free of infection. In preliminary screening tests, a potato clone is retained for further study if the percentage of hills developing disease is smaller than that for Irish Cobbler. In succeeding tests, replicated plots of the retained clones and Irish Cobbler are planted, and further selection is based upon differences found to be significant by statistical analysis of the data.

Artificial Inoculation: The artificial inoculation procedure employed was a slight modification of that described previously (8) for evaluating resistance in tomato and tobacco to the same pathogen. Single-stemmed plants are grown in four-inch pots of soil in a greenhouse at 75° F. until the bud- or early-bloom stage. Two or three days before inoculation the plants are transferred to a greenhouse maintained at a warm temperature (minimum 85° F.). Usually 10 plants of each clone are used in a single test with each plant serving as a replication. Up to 35 clones, including a resistant and a susceptible clone as controls, are evaluated in a single test. Prior to inoculation the plants are randomized in each replication. All plants of a single replication are placed in a shallow galvanized-iron tray (2 x 4 feet) which supplies sub-surface water to the potted plants. Usually 10 such replicates (trays) are used in each test.

Inoculum is prepared from two virulent cultures of *P. solanacearum* (4). The bacteria are grown on potato-dextrose-agar medium for approximately 72 hours at 32° C. The bacteria are washed from the media with distilled water and the suspensions of both cultures mixed. The concentrated bacterial suspension is standardized with the Fisher Electrophotometer (A. C. Model, using B-425 filter) calibrated with distilled water. The

concentrated suspension is diluted until it gives a galvanometer reading between 30 and 45 per cent transmission of incident light. This stock suspension is further diluted to prepare inoculum having a light transmission between 97 and 98 per cent. The slightly opalescent inoculum suspension is generally used within 2 hours after preparation.

Plants are inoculated by flooding severed roots with the inoculum. Two radial cuts, about 3 inches deep, are made with a conventional butcher knife at the periphery of each pot. With an automatic pipetting syringe, 10 ml of suspension is placed in each of the two cuts.

Final disease readings are made 12-14 days after inoculation. First wilting symptoms of susceptible clones appear in about 7 days; by 12 to 14 days, susceptible varieties, such as Irish Cobbler, are nearly all dead. Disease readings are based on an index system in which 0 indicates no disease and 5, death of the plant, and the readings are tabulated and tested for significance by the analysis of variance. The retention of promising clones is based upon their mean index values compared with those of Prisca (resistant) and Irish Cobbler (susceptible).

Results

All potato clones studied are susceptible to *P. solanacearum*, however, in some clones disease symptoms appeared at a later date, and the disease progressed more slowly, than in susceptible Irish Cobbler. Initial disease symptoms appeared in the more resistant clones 2 to 3 weeks later than in Irish Cobbler (Fig. 1). This slower development of disease is interpreted as resistance even though the proportion of plants diseased was sometimes equal, at a later date, to that of Irish Cobbler. In addition, the plants and tubers of resistant clones succumbed more slowly to the disease than did those of susceptible varieties. Tuber symptoms resembled, to some extent, those caused by *Fusarium oxysporum*. The vascular discoloration was distinctly brown and largely confined to the invaded vessels. In contrast, vascular discoloration in freshly harvested Irish Cobbler tubers was predominantly gray, and this discoloration often extended into the surrounding parenchymatous tissue which became soft and watery (Fig. 2B).

The resistance of 3 clones (Prisca, 2983, and 2777) was compared with that of Irish Cobbler in a replicated date-of-harvest experiment. Sufficient plots were planted for three harvest dates at 2-week intervals. Katahdin and Green Mountain were included with only enough plots for the final date of harvest. On each harvest date, the plants and tubers were examined for disease symptoms and signs (Table 1).

The resistant clones became diseased more slowly than did Irish Cobbler. Prisca and clone 2983 were about equally resistant when evaluated on the basis of number of diseased hills and tubers. Clone 2777 was intermediate. Katahdin and Green Mountain were as susceptible as Irish Cobbler on the basis of diseased hills; however, Green Mountain tuber infection was not different from that for 2983 and Prisca.

The reaction of Green Mountain agrees with that reported by Eddins (2). Katahdin responded similarly in his tests, but tuber infection for this variety in the above experiment (Table 1) exceeded that for Irish Cobbler. In this investigation, Katahdin and Green Mountain were studied for several years. Each year they were recorded as susceptible on the

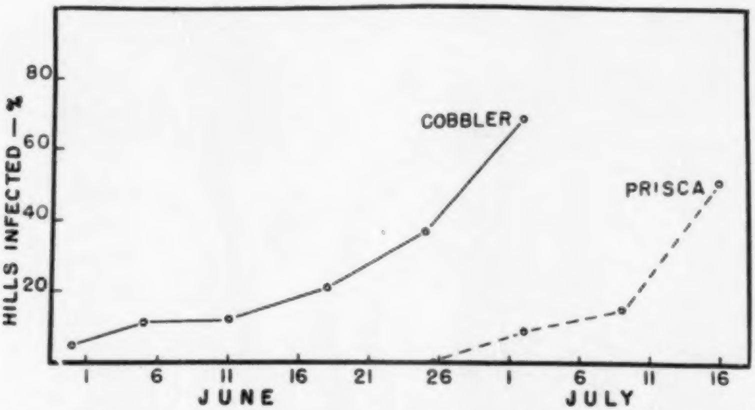

FIG. 1.—Comparative disease development in susceptible Irish Cobbler and resistant Prisca. The curves are based upon the cumulative proportion of diseased hills of the 2 clones growing under the same conditions in soil naturally infested with *Pseudomonas solanacearum.*

basis of diseased hills. Plants and tubers of these varieties are similar to Prisca in that they succumb to the disease more slowly than does Irish Cobbler (Fig. 2B).

The resistance found in the field tests was also demonstrated with artificial inoculations (Fig. 2A), and there was a correlation between the two methods of disease evaluation (Table 2). Although the correlation is not perfect (as in the case of clones 2407-12, 2446-14 and others), it is sufficient ($r = 0.6747$) to provide one with some confidence that many susceptible clones can be eliminated from a population by ~~the artificial~~ inoculation method. Significant correlations were obtained from tests performed two other years, but each year there were discrepancies between the inoculation index and natural infection of some clones. A consideration

TABLE 1.—*Relative number of hills and tubers of several potato clones infected by Pseudomonas solanacearum at three dates of harvest.*

Clone	Percentage of disease					
	June 4		June 18		July 3	
	Hills	Tubers	Hills	Tubers	Hills	Tubers
Irish Cobbler	15.0	6.5	53.0	27.2	72.2	36.5
Prisca	0.0	0.0	2.5	1.1	20.3	5.8
2983[1]	0.0	0.0	0.0	0.0	11.2	6.4
2777[2]	0.0	0.0	5.0	1.3	48.1	24.3
Katahdin					76.2	48.3
Green Mountain					70.6	12.9
L.S.D. 5 per cent					13.5	10.4

[1]Selection from Green Mountain x Saranac.
[2]Selection from President x Katahdin.

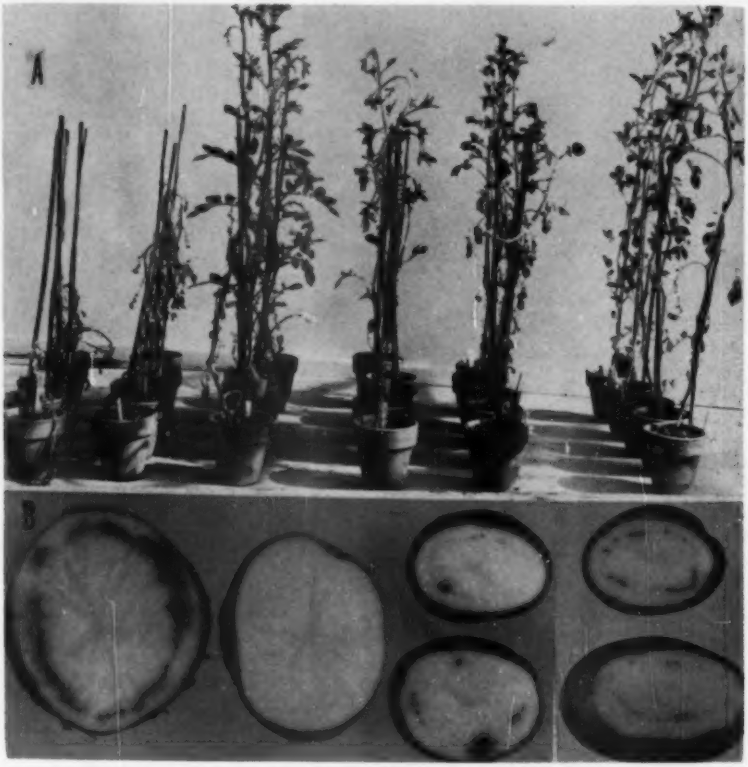

FIG. 2.—A) Relative disease development in six potato clones following artificial inoculation with *Pseudomonas solanacearum*. Susceptible Cobbler is row of dead plants at the left and resistant Prisca is at the right. B) Comparative internal symptoms of tubers from three clones: (left to right) Irish Cobbler—diseased and healthy, diseased Prisca, and Katahdin. Note extensive discoloration in tissue contiguous to vascular ring in diseased Irish Cobbler.

of disease resistance data for a number of clones over several years (Table 3) suggests that the discrepancies are most pronounced for clones whose resistance falls between that of susceptible Irish Cobbler and that of resistant Prisca.

The disease reaction of some clones varied from year to year but that of others did not. Irish Cobbler consistently had a high index and high field infection. Clones 2117-117 and Prisca consistently had low indexes and low field infection; these lines exemplify the highest type of resistance. Clone 2407-12 had an intermediate index, whereas clones 52B49-1 and 2446-14 were inconsistent. In some tests the disease indexes of the latter clones were equal to those of the most susceptible clones, whereas in other tests their indexes were in the range of the most resistant. The behavior

TABLE 2.—*Correlation between disease index following artificial inoculation with Pseudomonas solanacearum and field data obtained when the same clones were planted in infested soil.*[1]

Clone	Disease index[2]	Percentage of field hills with wilt
Prisca	1.2	7.7
Irish Cobbler	4.1	[3]
52B25-1	2.0	10.6
52B30-2	2.0	14.9
52B49-1	1.4	8.2
2117-117	1.0	1.8
2386-17	3.3	14.1
2392-81	3.0	23.4
2407-12	3.1	6.7
2407-23	0.9	10.3
2407-102	1.1	8.2
2410-78	1.0	12.9
2442-6	3.1	12.5
2446-14	1.0	10.7
2446-26	0.9	3.6
195145	3.0	28.9
195147	4.1	24.0
L.S.D.	1.9 (1 per cent level)	12.3 (5 per cent level)

[1]r (1%) = 0.6747
[2]Disease indexes: 0 = no symptoms; 1 = one leaf wilted; 2 = ⅓ of leaves wilted; 3 = ⅔ of leaves wilted; 4 = all of leaves wilted; and 5 = plant dead.
[3]Irish Cobbler matured before disease developed extensively.

TABLE 3.—*Relative disease readings (bacterial wilt) of resistant potato clones, in contrast to those of susceptible Irish Cobbler as determined by laboratory and field tests over several years.*

Clone	Disease index[1]					Percentage of field hills with wilt[2]		
	1954	1955	1956	1957	1958	1955	1957	1958
Irish Cobbler	4.1	4.1	4.8	4.6	4.9	[3]	58.3	53.0
Prisca	1.9	1.2	3.0	2.0	1.7	7.7	3.0	6.8
2117-117	1.8	1.0	2.4	0.6	2.3	1.8	3.5	
2407-12	2.4	3.1	3.6	3.8	2.1	6.7	5.5	1.6
2446-14	1.9	1.0	3.5	2.5	4.6	10.7	19.8	8.0
52B49-1	2.8	1.4	3.1	4.5	3.4	8.2	5.5	12.1
L.S.D. 5 per cent	1.4	1.4	1.2	1.4	[4]	12.3[5]	15.1	15.9
1 per cent	1.9	1.9	..	1.8			20.0	21.3

[1]Laboratory test involving artificial inoculation with *Pseudomonas solanacearum*. Ratings were on a scale of 0 to 5 as described in Table 2.
[2]Data from field tests in infested soil.
[3]Irish Cobbler matured before plants developed symptoms.
[4]No L.S.D. value common to all data, as values were from two tests.
[5]This value derived from data on resistant clones in test. The largest mean percentage of infected plants was 28.9.

of these and similar clones presumably reduced the correlation between greenhouse and field tests.

Hybridization Studies: Various clones exhibiting resistance were crossed to determine if resistance is heritable and whether the degree of resistance might be enhanced by hybridizing clones with different genetic backgrounds. In all cases, the progeny from crosses were first selected for acceptable horticultural types and these were subjected to the artificial inoculations. It is recognized that the genetic factors responsible for resistance to bacterial wilt may be closely linked to those for undesirable horticultural qualities and that selecting acceptable horticultural clones may eliminate clones with superior resistance.

The resistance previously found in potato clones was heritable (Table 4). Although the number of progeny tested from each hybrid combination was small, there were indications that some crosses (54C2 and 56C9) were more successful than others (53C7 and 53C20) in yielding resistant progeny possessing desirable horticulutral qualities. There was no evidence that resistance in the progeny was increased by combining factors of different genetic sources. None of the resistant clones was superior to Prisca.

Some progeny from the hybridization studies were exposed to natural infection under field conditions in 2 tests involving 21 clones (one or more from each of the family lines in Table 4, except 54C1) representing the susceptible (5 clones), intermediate (9 clones), and resistant (7 clones), disease reactions described above. All were resistant in comparison with susceptible Irish Cobbler, and 15 had resistance equal to that of Prisca; however, only 9 had approximately the same proportion of infected hills (5 per cent) as did Prisca. None of the clones was more resistant than Prisca.

All resistant clones studied possess the late-maturing character which is undesirable for the medium-early potato growing area of North Carolina.

TABLE 4.—*Disease reaction, following artificial inoculations with Pseudomonas solanacearum, of progeny of various crosses between potato clones.*

Family line	Parentage	No. of progenies tested	No. of progenies giving indicated disease reaction		
			Susceptible	Intermediate	Resistant
53C7	NC 901-5 x Prisca	8	7	1	
53C20	Prisca x NC 901-5	7	6	1	
53C21	Prisca x (Green Mountain x Saranac)	6	4		2
53C22	(Houma x Katahdin) x Prisca	7	4	1	2
53C24	Prisca selfed	10	5	4	1
54C1	Prisca x (Wulung[1] x Cimball's Neue Imperator)	9	7	1	1
54C2	Prisca x (Wulung[1] x Libertas)	9	3	4	2
56C8	Prisca x S. chacoense (4n)	4	2	2	
56C9	Prisca x B2609-36	19	11	4	4
Totals:		79	49	18	12

[1]Wulung, also spelled Woeloeng (7), is a Javanese potato resistant to *P. solanacearum.*

Discussion

The level of resistance found in *S. tuberosum* to *P. solanacearum* is relatively low and might be compared with that first discovered in tobacco (1) and tomatoes (8). In regions where soil temperatures and moisture are adequate for disease development throughout the growing period of the plant, the resistance in these potatoes would possibly be inadequate. In eastern North Carolina, however, where the soil temperatures are rarely warm enough for disease development until late May, the resistance may be sufficient to permit an early variety of potatoes to mature and to escape much of the inevitable tuber decay that now occurs with existing early varieties.

A source of resistance to *P. solanacearum* approaching immunity is highly desirable for a potato-breeding program. The evaluation of many breeding clones of *S. tuberosum* existent in the United States indicates that discovery of superior resistance in further surveys of this species is not encouraging. The success in finding resistance to other potato diseases in related *Solanum* species suggests that these species may be sources of superior resistance to *P. solanacearum*, particularly, those species that have evolved in sub-tropical or tropical regions where the bacterium is indigenous. The finding that the resistance found in *S. tuberosum*, and that previously reported for *Solanum* species is heritable (7), indicates that a superior resistance found in other species might be incorporated into acceptable types of *S. tuberosum* providing they are compatible in a hybridization program.

Summary

Numerous domestic and some foreign breeding clones of *Solanum tuberosum* were planted on soils naturally infested with *Pseudomonas solanacearum* in eastern North Carolina or were artificially inoculated. Several clones were found to possess a resistance expressed as a delayed appearance of symptoms and a slow development of disease in plants and tubers. All of the resistant clones are medium to late maturing. The resistance was found to be heritable, but the resistance obtained by hybridization of resistant clones of different genetical background was no better than that of the parents.

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STUDIES IN THE APPLICATION OF INFRA-RED FOR THE PRODUCTION OF FRENCH FRIES[1]

W. P. Mohr, E. A. Asselbergs and W. E. Ferguson[2]

The production cost of french fries is determined mainly by the cost of raw potatoes, peeling efficiency, fat consumption and frying yields. The fat consumption reportedly varies between 8.8 and 16.1 per cent (2) and is influenced by such factors as frying temperatures, temperature recovery, wetness of the potatoes and quality of the fat. The frying yield after the first stage fry, which is of importance in the production of oil-blanched french fries in the prepeeling industry, varies between 100 and 60 per cent depending upon the technique used, water content of the potato, size of cut, frying time and fat temperature. These same factors determine the frying yield after the second stage fry.

The present study was designed in an attempt to reduce oil consumption and weight losses during frying by the application of infra-red heat.

Materials and Methods

The Sebago variety of potato, obtained on the local retail market, was used for all tests. The testing period was between January and May, 1959. Before use the potatoes were conditioned at room temperature for 14 to 20 days.

The three types of infra-red radiators used included calrods, quartz tubes and quartz lamps (1). The calrod heating tunnel was made up of two 6-foot radiant panels, each equipped with an aluminum reflector and two 3000 watts heating units.[3] The distance between the calrod units and the product on the stainless steel wire belt could be varied from 3 to 20 inches. The quartz tube tunnel and the quartz lamp tunnel were similar in design to the calrod tunnel. The quartz tube tunnel, however, was equipped with five 6-foot, 3800 watts units[4] and the quartz lamp tunnel with five 38-inch 3800 watts units.[5]

For the heat penetration rate and weight loss study, cylindrical plugs 1½" x 1" were cut from peeled tubers and held in cold water until used. Preliminary tests showed that position in the tuber from which plugs were taken did not significantly affect heat penetration and weight loss data. A group of six potato plugs was used for each test. Each group was weighed before and after exposure in the tunnel. Immediately after removal from the tunnel the plugs were cut in half longitudinally and the thickness of the layer of cooked tissue at each end of the potato plug was recorded.

For the frying studies the potatoes were peeled, trimmed and cut into strips of ½" x ½" cross section. The French fries were prepared using

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[2]Food Technologist, Sr. Food Technologist and Microbiologist, respectively.
[3]General Electric, type OXIAA.
[4]Quartz Products Corp., infra-tube.
[5]General Electric, quartz lamps type A-105-7.

steam, deep fat fryer[6] and the infra-red tunnels. Shortening[7] of uniform quality was used for all tests. The first stage fry was defined as either a "short", "near", or "cooked" condition, indicating three progressive degrees of cooking. The second stage fry produced a "well cooked" condition as judged by the panel members. For the quality evaluation the following rating system was used by the four members of the taste panel·

	Rating	*Color*	*Texture*	*Flavor*
Acceptable	Excellent	Uniform, bright golden brown	Light, mealy, not greasy	Characteristic good flavor
	Good	Uniform, fairly bright golden brown	Light, fairly mealy	Fairly good flavor
Not acceptable	Fair	Slightly dull brown	Slightly soggy or greasy	Slightly flat
	Poor	Dull	Soggy or greasy	Flat and off flavor

The tests for the heat penetration rate and weight loss studies as well as for the frying studies, were made in triplicate. Average results are reported.

The effect of freezing and cold storage between the first and second stage on the quality of the french fries was determined on samples packaged in polyethylene bags, sealed and stored at 0° or 38° F.

Tests for peroxidase activity (3), weight loss, fat content, flavor, color and texture were carried out on duplicate 200 gm. samples.

For the determination of microbial populations 10 grams of the treated potatoes were washed by shaking with 100 ml. sterile water in a horizontal mechanical shaker. Serial dilutions of the wash water were plated on Bacto tryptone glucose agar.

Results and Discussion

The heat penetration and weight losses in plugs of potato tissue after exposure to infra-red radiators for varying exposure times and at varying distances are shown in Fig. 1. The rate of heat penetration and the incidence of scorching varied with the type of heat source. Weight losses for each heat treatment closely paralleled corresponding penetration values. The quartz lamps and the calrods produced approximately equal penetration before surface scorching of the potato plugs occurred. However, the use of the calrods required impractical exposure times, e.g. 26 minutes at the 7 inch distance. The differences in the penetration rates as shown in Fig. 1 probably result from differences in total energy outputs and the wavelength characteristics of the radiators. The energy output of the quartz lamps is rated as 100 watts per inch as compared with 53 watts per inch for the quartz tubes and 41 watts per inch for the calrods. The quartz lamps have a peak wave-length at 1.15 mμ. as compared with 2.35 mμ. for the quartz tubes and 2.5 mμ. for the calrods.

[6]Moffat, model CF 4110.
[7]Domestic Shartening.

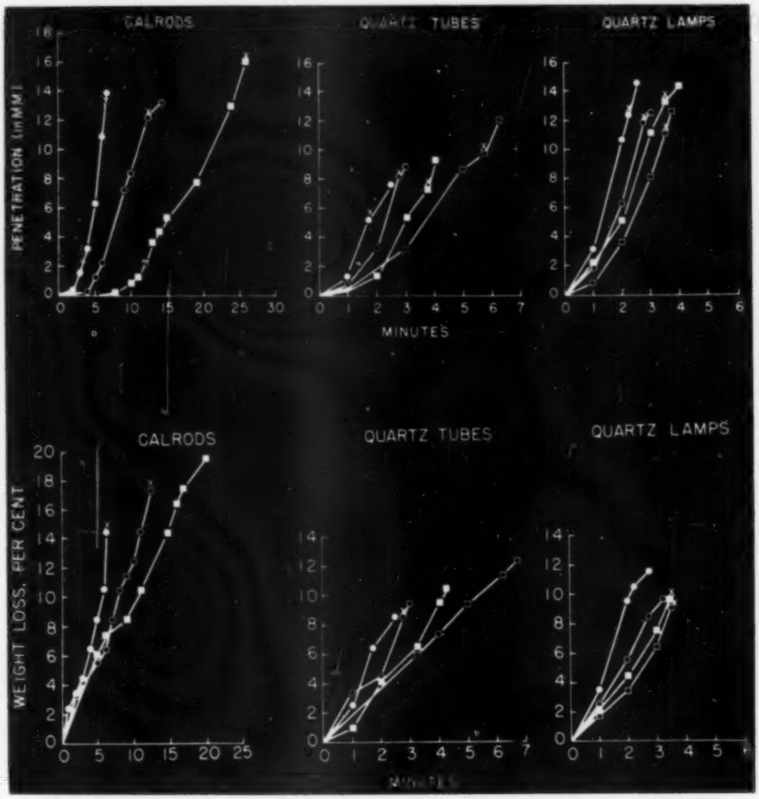

FIGURE 1.—Heat penetration and weight losses in 1½" x 1" cylindrical plugs of potato tissue, after exposure to infra-red radiators at various exposure times and distances.

● = 4" distance ○ = 5½" distance ■ = 7" distance □ = 8½" distance

*Indicates the stage at which the surface of the tissue scorched.

Because the deepest penetration in the shortest exposure time was produced by the quartz lamps at the 4 inch distance, this arrangement was used for all subsequent experiments .

The results of preliminary experiments showed that exposure of cut potatoes to infra-red did not produce a satisfactory brown color. Dipping the cut potatoes in liquid shortening at 175° F. prior to exposure to infra-red improved the appearance. However to obtain a golden brown color it was necessary to use the deep fat fryer for the second stage.

In Table 1 are summarized the data on the production of French fries prepared by different techniques.

Exposure to infra-red as the first stage treatment, followed by deep

fat frying for the second stage, produced only a fair product because texture and flavor were not acceptable. An improved quality and smaller weight loss were obtained when the cut potatoes were dipped in liquid shortening prior to exposure to infra-red. Weight loss after this first stage was considerably less than in the previous treatment. This is of particular importance in the production and distribution of oil-blanched French fries in the prepeeling industry. The quality of these French fries, after the second stage in a deep fat fryer, was rated good. Moreover, weight loss after the second stage was less than that of any other treatment. Steam-blanching of the cut potatoes followed by deep fat frying produced a product rated only fair for texture and flavor.

The quality evaluation of French fries, prepared by deep fat fry, infra-red or a combination of these techniques and stored at 0° F. between the first and second stage, is summarized in Table 2. The combination of fat dip and infra-red as the first stage treatment again produced the lowest weight loss and fat absorption. However, the color and appearance of the cut potatoes at this stage were not attractive. These characteristics were greatly improved by application of a 30-second deep fat fry treatment immediately after exposure to infra-red. Although the preparation time for the stage one treatment was not altered, the inclusion of the deep fat frying treatment resulted in a small increase in weight loss and fat absorption. After storage at 0° F. for 6 weeks the samples were finished off in a deep fat fryer. The weight losses during this second stage preparation were inversely related to the weight losses in the first stage preparation. Deep fat frying for the first and second stages resulted in the largest total weight loss and fat absorption. The quality of all samples after the second stage was considered fair, mainly because of poor texture.

The quality evaluation of French fries prepared by a dip and exposure to infra-red followed by deep fat frying, and stored at 38° F. between the first and second stage, is summarized in Table 3. The quality of the french fries, judged after the second stage preparation, was rated as good after 9 days of 38° F. storage. After 12 days, the quality was only fair because of the presence of a "storage" off-flavor. Microbiologically, no deterioration occurred for a period of 14 days at 38° F.

Summary and Conclusions

1. Exposure of the cut potatoes at a distance of 4 inches from infra-red quartz lamps resulted in faster heat penetration than exposure to quartz tube or infra-red calrod units; the rated wattages per linear inch of these radiators were 100, 53 and 41 watts, respectively.

2. Oil-blanching of French fries with infra-red quartz lamps resulted in approximately 8 to 12 per cent higher product yield after the first stage preparation and a 4 to 8 per cent higher product yield after the second stage preparation, as compared with conventional deep fat frying.

3. A 2 to 4 per cent lower fat content in the stage one and stage two product was obtained by use of the infra-red treatment.

4. Storage of french fries at 0° F. between stage one and stage two produced a finished product of only "fair" quality, regardless of the technique used to prepare the first stage product.

TABLE 1.—*The production of French fries using different techniques.*

Stage 1	Degree of cook	Peroxidase activity	Stage 2	Time (Minutes) Stage 1	Time (Minutes) Stage 2[3]	Weight loss (Per cent) Stage 1[4]	Weight loss (Per cent) Stage 2[5]	Weight loss (Per cent) Total[4]	Fat content (Per cent) Stage 1[4]	Fat content (Per cent) Total[6]	Acceptability
DFF 375°F.[1]	cooked	neg.	..	3½	..	33.5	..	33.5	..	4.0	good
DFF 400°F.	cooked	neg.	..	3	..	36.5	..	36.5	..	5.6	good
Infra-red	near	pos.	DFF	2¾	1½	22.3	19.0	37.0	0.6	3.5	fair
FD and I-R[2]	near	neg.	DFF 350°F	2¾	1½	16.6	17.2	30.0	2.2	4.1	good
FD and I-R[2]	near	neg.	DFF 375°F.	2¾	1	16.6	13.1	28.0	2.1	4.6	good
FD and I-R[2]	near	neg.	DFF 400°F.	2¾	¾	16.8	11.7	26.5	2.4	5.0	good
Steam	near	neg.	DFF 375°F.	3½	3	0	37.0	37.0	0.2	6.9	fair
Steam	near	neg.	DFF 400°F.	3½	2½	0.5	36.0	36.0	0.2	4.5	fair

TABLE 2.—*Quality evaluation of French fries prepared with infra-red and deep fat fry and stored at 0° F. between stages.*

Stage 1	Degree of cook	Peroxidase activity	Stage 2	Time (Minutes) Stage 1	Time (Minutes) Stage 2[3]	Weight loss (Per cent) Stage 1[4]	Weight loss (Per cent) Stage 2[5]	Weight loss (Per cent) Total[4]	Fat content (Per cent) Stage 1[4]	Fat content (Per cent) Total[6]	Acceptability
DFF 375°F.	short	neg.	DFF 375°F.	2	¾	24.8	3.3	27.3	4.1	10.6	fair
	near	neg.	DFF 375°F.	3	¾	31.2	2.7	33.0	6.0	9.5	fair
FD and I-R	short	pos.	DFF 375°F.	2¼	1	12.3	11.7	22.5	2.3	7.4	fair
	near	neg.	DFF 375°F.	2¾	¼	18.8	9.2	26.3	2.4	7.9	fair
FD, I-R and ½ min. DFF 375°F.	short	pos.	DFF 375°F.	2¼	1¼	17.0	9.0	24.5	2.7	8.9	fair
	near	neg.	DFF 375°F.	2¾	¾	19.0	7.4	25.0	3.5	8.4	fair

[1]DFF = Deep fat fry.
[2]FD and I-R = Fat dip and infra-red.
[3]Time interval between stage 1 and 2 was 1-2 hrs. at room temperature.
[4]Raw weight basis.
[5]Stage 1 weight basis.
[6]Stage 2 weight basis.

TABLE 3.—*Quality evaluation of French fries prepared with infra-red and deep fat fry and stored at 38° F. between stages.*

Stage 1	No. Days at 38°F. storage	Bacterial count/gm.	Stage 2	Weight loss (per cent)			Acceptability
				Stage 1	Stage 2[1]	Total[2]	
FD and 2¾ min. I-R, near cook, peroxidase negative.[3]	0	< 300	DFF at 375°F. for 1¾ min.	..	..	..	good
	3	< 300		17.0	21.7	35.0	good
	6	< 300		16.8	18.9	32.5	good
	9	< 300		16.0	20.0	31.5	good
	12	< 300		15.3	19.3	32.0	fair
	15	80,000		16.7	18.5	32.1	fair
	18	440,000		..	..	..	..
FD and 2¾ min. I-R, ½ min. DFF at 375°F., cooked, peroxidase negative[3]	0	< 300	DFF at 375°F. for 1 min.	..	..	..	good
	3	< 300		22.5	16.1	35.0	good
	6	< 300		21.3	17.5	35.5	good
	9	< 300		22.5	15.5	34.5	good
	12	< 300		21.0	13.9	33.0	fair
	15	< 300		22.5	13.3	33.0	fair
	18	12,000		22.0	14.5	33.3	fair
	21	46,000		..	..	..	..

[1]Stage 1 weight basis.
[2]R..w weight basis.
[3]FD = Fat dip, I-R = Infra-red, DFF = Deep fat fry.

5. French fries, prepared by infra-red and deep fat frying, resulted in a finished product of "good" quality when stored up to 9 days at 38° F. between the first and second stage.

ACKNOWLEDGMENTS

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FUNDY: A NEW SMOOTH, EARLY MATURING VARIETY OF POTATO[1]

L. C. YOUNG, H. T. DAVIES, D. A. YOUNG AND J. MUNRO[2]

The Fundy potato is a product of the National Potato Breeding Program of the Canada Department of Agriculture.

This variety has been under close observation in New Brunswick for nine years as seedling F503. It has been tested extensively in the Maritime Provinces and evaluated in the system of National Trials throughout Canada.

ORIGIN

The Fundy potato originated from a cross between the Canadian variety Keswick and the USDA seedling 96-56 and was first grown in the field in 1950.

The pedigree is as follows:

- Fundy
  - USDA 96-56
    - Earlaine
    - USDA 3895-13
  - Keswick
    - Green Mountain
    - F1020-1
      - Earlaine
      - F581-16
        - Earlaine
        - F333-1
          - Earlaine
          - *Solanum demissum*

DESCRIPTION

Top—Habit and General Appearance:

Medium height, slightly spreading, open, not bushy, slightly straggling. Stems with only an occasional branch. Medium vigour.

Leaves:

Leaf close. This feature is only apparent on lower leaves that have no roll. The leaves of this seedling have a tendency to develop a slight to pronounced rim roll, depending on the degree of maturity. When this roll is present, the leaf appears open. Midrib green. Leaf green, slightly wrinkled, glossy, medium length, drooping, side leaflets arched.

Leaflets:

Large, broad; terminal pair of leaflets slightly overlap terminal leaflet; leaflet petiole medium to long; secondary leaflets present; terminal leaflet drooping, not joined to adjacent side leaflets.

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[2]Potato Breeding Section, Research Station, Fredericton, N. B.

Stem:

Medium thick, wings straight or slightly waved, hollow between nodes. No colouring other than green present on above-ground portion of stem. Below ground level, the stem is white, tinged with purple.

Flowers:

White, rather sparse. Anthers yellow, Style long, stigma green and bi-lobed. The pedicel is short to medium in length, thin, hairy, light green and without leaves. It arises well down the stem, consequently, blossoms do not stand above top of plant to any extent. Seed balls not set in field.

Tubers:

Medium size, elliptical, medium thick, mean length 3.37 inches, mean width 3.00 inches, mean thickness 2.25 inches. Skin smooth, dark cream buff, slightly netted. Eyes shallow, same color as skin. Eyebrow long, curved, prominent. Flesh white.

General Description

The plants are of moderate vigour with a slightly spreading habit. The maturity is early to mid-season. The flowers are white and rather sparse. The leaves are slightly crinkled and have a tendency to rim roll as maturity advances. The tuber is smooth, slightly netted, shallow-eyed, elliptical, medium thick, of excellent type and very atractive in appearance.

Yield and Dry Matter Content

The yield of Fundy in New Brunswick is slightly superior to Katahdin, and the tubers rate medium in dry matter content. Fundy was included in replicated yield trials at three locations in New Brunswick over a four year period (Table 1). On an average, based on nine trials, Fundy yielded 479.4 bushels of Canada No. 1 tubers per acre as compared with 440.0 bushels for the variety Katahdin. In the same trials, the average per cent dry matter[3] for Fundy was 17.4 as compared with 17.2 for Katahdin.

Advanced National Trials:

Fundy was included in the Advanced National Trials for the three year period 1955, 1956 and 1957. The figures below are averages for the three year period.

At Fredericton, the yield of Fundy in bushels per acre of Canada No. 1 tubers was 450 as compared with 440 for Avon, 369 for Katahdin, 402 for Irish Cobbler, and 493 for Green Mountain.

The percentage dry matter was as follows: Fundy 18.5; Avon 18.1; Irish Cobbler 19.3; Katahdin 18.3; Green Mountain 20.2.

Averaging the results of the three trials in the Maritime Provinces at Fredericton, Charlottetown and Kentville, Fundy gave a yield of 388 bushels per acre of Canada No. 1 tubers as compared with 390 for Irish Cobbler, 421 for Avon and 513 for Green Mountain. This wide difference in favor of the late variety Green Mountain was due to the results at

[3]All dry matter percentages determined with the Bewell Potato Hydrometer. In the author's experience, this instrument reads 1 to 1.5 per cent lower than the National Potato Chip Institute Hydrometer.

TABLE 1.—*Yield and dry matter data of Fundy and Katahdin at three locations in New Brunswick 1955-1958.*

Year	Location	Fundy		Katahdin	
		Bu./Acre Canada No. 1 tubers	Per cent dry matter	Bu./Acre Canada No. 1 tubers	Per cent dry matter
1955	Salmonhurst	552.7	16.4	490.9	16.1
1956	McDonald's Corner	283.3	19.2	285.5	18.1
1956	Salmonhurst	458.2	16.6	474.0	16.9
1956	Centreville	564.2	16..4	540.9	16.7
1957	McDonald's Corner	507.2	17.4	461.0	18.1
1957	Salmonhurst	582.6	16.8	506.7	16.5
1957	Centreville	322.7	17.5	354.1	17.0
1958	McDonald's Corner	493.0	19.5	414.8	19.9
1958	Salmonhurst	550.5	16.5	431.7	15.9
Average 9 trials		479.4	17.4	440.0	17.2

Kentville, where Fundy gave a yield of 386 bushels per acre of Canada No. 1 tubers as compared with the abnormally high yield of 632 bushels for Green Mountain. The percentage dry matter was as follows: Fundy 17.7; Irish Cobbler 17.7; Avon 17.4; Green Mountain 18.3.

Since Fundy is an early variety, comparison with the variety Irish Cobbler is of particular interest. Irish Cobbler and Fundy were grown in the Advanced Trials over a three year period at five locations; Guelph, Ontario; Ste. Anne de la Pocatiere, P. Q.; Fredericton, N. B.; Kentville, N. S.; and Charlottetown, P. E. I. Average yields of Canada No. 1 tubers in bushels per acre were as follows: Fundy 355, Irish Cobbler 364. The dry matter content for Fundy was 18.3 per cent as compared with 18.1 per cent for Irish Cobbler.

COOKING TRIALS

Fundy has rated excellent in cooking quality at Fredericton over a five year period, being much better in this respect than its dry matter content would indicate. In the cooking trials, the various lots were coded, and then boiled and baked, using three tubers at a time. Tubers, containing a dry matter content equal to the average for the variety, were selected for cooking purposes. All lots were scored by an experienced panel, and the scores were averaged to obtain the rating for the variety (Table 2).

On the basis of six tests, Fundy scored 86 when boiled as compared with 76 for Katahdin and 80 for Green Mountain. When baked, Fundy scored 90 as compared with 81 for Katahdin and 81 for Green Mountain.

In limited chipping tests over a three year period, Fundy was rated as not being satisfactory for chip manufacture.

DISEASE REACTIONS

Late Blight: Fundy carries the gene R1 for resistance to late blight. In this respect, it is in the same category as such varieties as Keswick, Canso and Kennebec.

TABLE 2.—*Cooking scores*[1] *of boiled and baked samples of Fundy potatoes and two check varieties.*

Year	Boiled			Baked		
	Fundy	Katahdin	Green Mountain	Fundy	Katahdin	Green Mountain
1953	72	78	85	79	73	69
1954	93	80	71	95	77	77
1955	84	88	93	92	97	97
1956	91	61	69	88	76	82
1957	87	81	89	94	86	87
1958	88	68	75	89	77	75
Average 6 years	86	76	80	90	81	81

[1]Total possible score 100, rated on the texture, color and flavor of the cooked sample. In boiling, the degree of sloughing is also recorded.

Virus Reactions: Fundy is susceptible to the common strains of virus X. The severity of the disease ranges from rugose mosaic to barely visible mottle depending upon the strain of the virus. Some strains do not cause any visible symptoms of disease. It has been shown that under conditions not too well defined, some severe strains of this virus will multiply more quickly than mild strains when they are together infecting the same plants. In 1957, a severe mosaic developed in this variety that had not been seen before. This sudden development of a severe strain within a mixture of mild field strains and commonly observed in Green Mountain, probably occurs at some time in all varieties susceptible to virus X.

Fundy reacts to virus Y with a rugose mosaic disease of varying intensity according to the strain. It is susceptible to Virus A and top necrotic to virus B.

SUMMARY

Fundy is a new variety of potato developed within the National Potato Breeding Program of Canada. It is early to mid-season in maturity, and superior to most early varieties in that the tubers are shallow-eyed and attractive in appearance. It approximates Irish Cobbler in yielding ability. When grown as a main crop in New Brunswick, it has outyielded Katahdin by a small margin. Although rating only medium in dry matter content, it has excellent cooking quality both for boiling and baking purposes. It carries the gene R1 for resistance to late blight.

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A BIBLIOGRAPHY OF FARM BUILDINGS RESEARCH 1945-58 PART II. BUILDINGS FOR POTATO STORAGE

The Agricultural Research Council, London, England, is compiling a general bibliography of research publications on farm buildings. This is the first bibliography of this subject to be undertaken.

Buildings for Potato Storage is the second section of this bibliography to appear. It will be followed by other sections dealing with buildings for poultry, cattle, for the drying and storage of grain and for the processing and storage of forage. There will also be a general section which will deal with miscellaneous types of building and with the construction and maintenance of farm buildings. The first section, "Buildings for Pigs", price 2/6d (by post 2/10d) was published in November, 1959.

The bibliography regards farm buildings as part of farm equipment and therefore gives references to any matter affecting their design, construction, economics and use. It includes the findings of scientific research, of such systematic but less precise forms of investigation as surveys, and of field trials and similar developmental phases of new techniques. It includes information from any country where conditions are relevant to Great Britain. It gives abstracts of the original material and a review summarising the main conclusions.

The present bibliography covers the period January 1st, 1945 to April 30th, 1958. The Council intends to keep it up to date by publishing supplementary bibliographies from time to time.

Buildings for Potato Storage, price 2/–d (by post 2/4d) (2 shillings and four pence) is obtainable from the A.R.C. Farm Buildings Unit, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds, England, or through the Potato Association of America.

INSTANT POTATO PRODUCTS ASSOCIATION FORMED

The newly formed Instant Potato Products Association, representing, a $25 million industry with a phenomenal growth record of 50 per cent over the past year, has undertaken an intensive promotional program to better acquaint housewives with the benefits of instant potato products. Factors such as taste, convenience, economy, storage ease, keeping quality, and controlled portions are emphasized in editorial features directed to all consumer media, in recipe booklets, and in special demonstration material beamed at cooking schools, utility companies, and home economics classes.

Fourteen founding member firms, representing both producers and marketers of instant potato products, have elected as president of the association William Parker, Rogers Bros. Co., Idaho Falls, Idaho. Leon Jones, J. R. Simplot Co., Caldwell, Idaho, was elected vice president, and John Trocke, The Frito Co., Rogers City, Michigan, secretary-treasurer.

Appointed to an executive steering committee comprising the officers were W. B. Cash, General Mills, Inc., and R. D. Jones, the Pillsbury Co.

The Instant Potato Products Association has set up headquarters at 333 North Michigan Avenue, Chicago 1, Illinois.